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# A presentation of four cases of organisational learning in a steam cracker

*An exploration of organisational learning*

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# ***A PRESENTATION OF FOUR CASES OF ORGANISATIONAL LEARNING IN A STEAM CRACKER***

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## 1. Introduction

In this paper we will first recapitulate our theoretical framework and provide a definition of organisational learning, which will be further expanded on, amongst others by making use of a number of criteria, which have been developed by the Orglearn research consortium. After this short theoretical recapitulation, we will take a short virtual tour through Company B to end up at the steam cracker plant.

In a following part, our four cases of organisational learning in the steam cracker will be presented. This paper is structured in such a way that we will first give you some background on a case, then discuss the case in detail to then make the link with organisational learning.

A first case is about the *re-evaluation of standard procedures*. We will have a look at what a standard operating procedure is exactly, what the role of a plant manual is and how operators can make suggestions for improvement on the standard operating procedures. A second case is the *competence management system* they have implemented at Company B and at the steam cracker. First we will have a look at the job of an operator, then investigate the organisation of labour at the steam cracker and indicate some pitfalls to finally show you how this is a case of organisational learning. In a third case we will have a look at the *organisational structure* of Company B and indicate how this structure provides learning and knowledge sharing possibilities, which would otherwise not be present. In a final case, we will describe a unique situation while we were doing our research, namely the occurrence of critical incident. We will indicate what happened and which initiatives have been taken to prevent something similar from happening again.

In a conclusive part, we will present you an overview matrix, showing how these cases are related to the five criteria of organisational learning.

## 2. Theoretical outlay

Before we present the company and the resulting cases of organisational learning in detail, we will first recapitulate some important parts of our theoretical framework, as laid out in a previous publication (Fisher & Roeben, 2001).

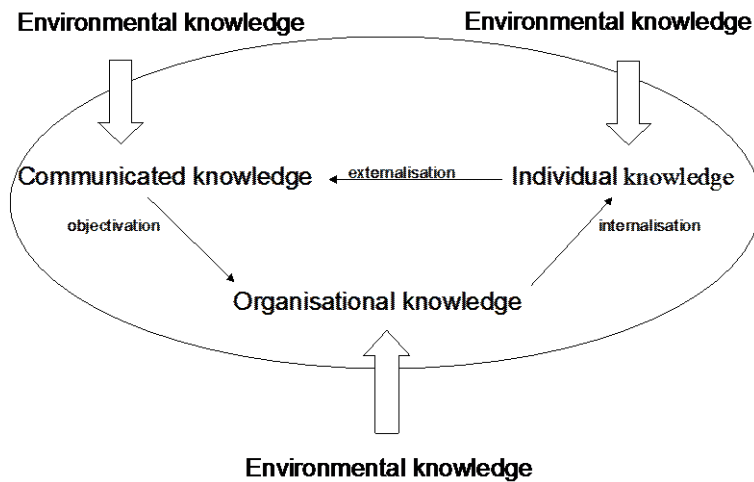
In his contribution to this framework, Mariani (2001) refers to an article by Snyder & Cummings (1998) who defines learning as organisational “to the extent that: (a) it is done to achieve organisation purposes; (b) it is shared or distributed among members of the organisation; (c) learning outcomes are embedded in the organisation’s system, structures and culture”. This definition of organisational learning emphasises organisational knowledge creation and dissemination. As a result, in this paper we will focus on the aspect of the construction, the distribution and the institutionalisation of knowledge. This implies that we will look at how new knowledge, that can be gathered from the environment or that can be created within the organisation, affects how organisational work routines are being evaluated. This structural aspect of learning and of knowledge creation, retention and dissemination forms one of the pillars of the framework as elaborated on by our research group. As Argyris and Schön argue, organisational learning in the sense of double-loop and deuterio learning “implies that the organisation has created a *structure* through which individual learning is permanently stimulated, documented and evaluated” (Boreham, Fisher et al., 2001: 132).

Berger and Luckmann (1966) give a description of the process of institutionalisation in their principal work ‘The social construction of reality’. How can this process of institutionalisation be regarded? Huysmans & van der Vlist (1998) define it as “a process in which social practices become sufficiently regular and continuous in order to regard them as institutions that have a normative, compulsory influence on the behaviour of members of an organisation”.<sup>1</sup> This process of institutionalisation can thus be regarded as a process, which is a central element to organisational learning to us, that individual knowledge is transformed into organisational knowledge.

Berger and Luckmann (1966) identify three stages that can be discerned during the process of institutionalisation: *externalising*, *objectifying* and *internalising*. The learning of an organisation can be looked upon from the viewpoint of these three stages.

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<sup>1</sup> The author of this paper has made the translation.



Source: Adaptation of figure, based on Huysmans & van der Vlist (1998)

**Figure 1.** Learning as a process of institutionalisation

During the process of *externalisation*, personal knowledge is transferred to others. This can happen in different ways, through formal and informal channels, by personal contact or by use of communication technology. This knowledge can be *objectified* by the organisation in the form of rules, procedures, structures, etc. and can thus function as a kind of organisational memory. This doesn't mean that this organisational memory is static. Objectified knowledge is also liable to change. Through *internalisation*, an employee reabsorbs this organisational knowledge, in order to become, and remain, a member of the organisation.

This process of organisational learning through the institutionalisation of knowledge, as described above, follows a circular motion. This however does not mean that this circle is fully closed. It is permeable to knowledge from the environment, which can influence the individual, the communicated and the organisational knowledge at any stage. This means that external knowledge can influence the individual, communicated and organisational knowledge at any time.

We can illustrate this process by means of an analogy of finding how to get from place X to Y. When an individual knows how to get there, we can call this individual knowledge. If he explains this to someone else, this is communicated knowledge. But to avoid that this person has got to explain this every time someone doesn't know how to get there, it is possible to draw a map. This map is objectified knowledge or organisational knowledge. From the moment on that other people start using this map, they are internalising this knowledge. What we try to study, is how these maps come into being.

Essential to this framework are the five criteria that have been developed by the Orglearn research consortium. These criteria that stem from the theoretical framework will in a later stage be used to relate our cases. In a previous paper

(Fisher & Roeben, 2001), these criteria have been elaborated. In short, they cover the evaluation of the work routines and of the formal and informal learning processes, the transformations in the culture of the organisation, the creation and dissemination of knowledge and the learning from the environment.

In what follows, we will present several cases of organisational learning within the steam cracker plant of Company B, but first, we would like to present the company and the role of the steam cracker.

### **3. Background of the steam cracker plant Company B**

In what follows we will present several cases of organisational learning within the steam cracker plant of Company B, but before, we would like to show you how this plant is embedded within the Company B Group.

#### **3.1 Company B**

##### **3.1.1 General introduction to the Company**

In 1865 Friedrich Engelhorn founded Company B in Germany to produce coal tar dyes and precursors. One hundred and thirty six years later the Company B Group has become one of the world's largest transnational chemical companies, with production plants in thirty nine countries and commercial representation in one hundred and seventy countries.

Company B in Antwerp then was established on the 1st of December 1964. Construction began soon afterwards and production started in the middle of 1967. It is now the largest chemical complex in Belgium and the Group's major production unit after the Ludwigshafen site. The site itself is situated on the Scheldt estuary to the north of the port of Antwerp and consists out of 54 plants, which make up integrated productions lines on a 600 ha site. With its direct access to the sea and to the European hinterland, Antwerp is BASF's premier maritime facility in Europe.

Apart from fertilisers and insulation panels, Company B mainly produces basic or semi-finished products, including basic chemicals and speciality chemical products used to finish paper and leather, for the production of detergents, paints, phytosanitary products, synthetic leather, etc.

##### **3.1.2 Employment**

On average 4,572 jobs were filled in at Company B in 1999. Of these jobs, 3,438 were filled in by their own workforce and 1,119 by people of contracting firms who provided a number of services to Company B. These subcontractors provide general technical services (construction, mechanical assembly and maintenance,



electrical activities and process-control technology), logistics and dispatching, transport, catering, cleaning, ... which do not belong to the core business of Company B as a chemical company.

The effect on indirect employment is even greater. Based on their own calculations, using the total amount of orders placed by Company B (approximately 2.7 billion orders/year), close to another 9,000 jobs exist as a result of the activities of Company B in Antwerp (Company B Social Report, 1999).

As we have already mentioned, there were 3,438 people employed at Company B at the end of 1999. Of this workforce, 56% were workers with an employee statute.<sup>2</sup> White-collar workers make up 32% of the workforce and executives 12%. About 6% of the total workforce are women. Among the white-collar workers, as among the executive staff, this is approximately 13%.

**Table 1.** The workforce at Company B by statute and gender

Per 31-12-1999	Men	Women	Total
Blue-collar workers (with employee statute)	1,936	1	1,937
White-collar workers	955	145	1,100
Executives	349	52	401
Total	3,240	198	3,438

Source: Company B Social Report, 1999

About half of the entire workforce of Company B works in shifts. About 70% of the blue-collar workers<sup>3</sup> work in a shift system. For white-collar workers, this number is about 39%. Although various shift systems are used at BASF, the most common system is that of a four shifts for one plant where each shift works one of the three shifts, which lasts for eight hours, following a rotations system.

The way this shift system is organised explains why there are relatively few women with an employee statute, because up until April the 8th of 1998, it was legally not permitted for women to work during the night shift in the chemical sector.

**Table 2.** The workforce at Company B by statute and shift

Per 31-12-1999	Day shift	Shift work
Blue-collar workers (with employee statute)	573	1,364
White-collar workers	670	430
Executives	401	-
Total	1,644	1,794

Source: Company B Social Report, 1999

<sup>2</sup> This statute, which brings the classic blue-collar statute closer to the white-collar statute, was developed at Company B and implemented in 1995.

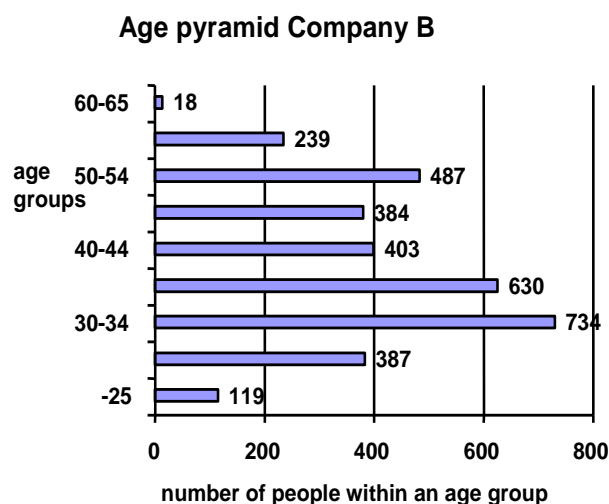
<sup>3</sup> These are employees with the aforementioned employee statute.

Also in 1999, the total personnel costs decreased by 1,1% compared to the year before, because of the lower number of employees and the fewer 'incidental personnel costs'.<sup>4</sup>

Although situated close to the border of the Netherlands, with regard to nationality, the Belgians are with 90% still in the majority within the workforce of Company B. Then come the Dutch and the Germans who represent respectively 5% and 2% of the workforce. Employees from different other countries like France, the UK, Italy, Morocco, Austria, Spain, Rumania, Tunisia, Turkey and the US make up the final one percentage. Among these we find 24 employees of the Company B group who are in Antwerp to acquire international experience. Conversely, 24 employees of Company B have been sent to different companies of the Company B group for the same reason. Furthermore, there are 15 Company B ex-patriots who are temporarily working abroad on specific Company B group projects.

### 3.1.3 Age and service

When taking a closer look upon the age distribution of the company, we notice that about 40% of the workforce employed by Company B is within their thirties. The group in their forties form the second largest age group with 24% of the workforce, followed closely by those in their fifties at 21%.



**Figure 2.** Age pyramid Company B

<sup>4</sup> Incidental personnel costs entail contributions for fringe benefit provisions (retirement plans and precautionary funds) and costs originating from personnel transport, company catering facilities, work clothing, insurance, etc.

What is of particular interest, is that the number of persons in the age group of fifty to fifty-five is larger than the number of people in both the age group of people from forty to forty-four and forty-five to forty-nine. This means that when the people in the age group of fifty to fifty-four leave the company, Company B will lose experienced people it cannot replace immediately. And this is where the concept of a learning organisation, which tries to gather the knowledge and experience of its workers, can play an important role.

When we look at the seniority pyramid of Company B, what strikes most, is the fact that more than two thirds have a service record of more than ten years within the company, and that of this group, more than half have got a service record of more than twenty years.

#### 3.1.4 Education and training

Company B recruited 121 new employees during 1999. Of these newcomers, 75 were blue-collar workers and 46 white-collar workers and executives. During this year Company B received a total of 2,246 job applications of which 640 candidates were withheld to participate in the selection process. The yearly average of new recruits from 1995 till 1999 is 105.

Not only newcomers need training and education. To stay abreast of the fast developing technology, education and training plays a large role in the overall personnel policy. Thus Company B spent a total of 10,029 man-days and 101 million BEF on training and education in 1999, not including on-the-job training. This amount does not include the cost of the non-productive hours, which amount to an additional 115 million BEF. Training courses were followed by a total of 2,676 employees in 1999, which amounts to a cost of approximately 38,000 BEF per employee being educated and 3,8 man-days. What Company B tries to accomplish with all the training they give is "to afford employees the opportunity to acquire, maintain and develop skills with which they can carry out their duties and fulfil their role in the realisation of the company vision" (Company B Social report, 1999). It is also stressed that besides technical training there is also training oriented towards social skills and company values.

#### 3.1.5 Verbund

The word 'Verbund' is a derivative from the German verb 'verbinden' which means to connect, to associate or to integrate. This word is considered an established concept within the company of Company B Group and is normally not translated. The concept originates from the vision that Friedrich Engelhorn had when he set up Company B Group in 1865. What he wanted to do, was to bring dye research and production under the same roof.

His vision was to link each production facility to other plants so that the finished products and the leftover material from one plant could serve as raw materials for another plant. Today Company B is such a Verbund site,<sup>5</sup> where all the plants are connected with one and other, by means of at least one product of one production process. In this framework, the construction of the steam cracker plant is a case of backward vertical integration, since it produces the base products for other plants. But the Verbund concept entails more than what is known as global integration (both horizontal and vertical), since Company B group also disposes of an energy Verbund, a logistics Verbund, an infrastructure Verbund, a market and customer orientation Verbund and last but not least a know-how Verbund. This last type of Verbund is related to the way knowledge is created and transferred within Company B. How individual knowledge is brought together, organised, evaluated and made available across departments, divisions, countries, we will show in a following chapter, when we discuss several cases of organisational learning in detail.

### 3.2 The Steam Cracker at Company B

We have just explained that Company B is an integrated site on different Verbundlevels. Although the steam cracker is one of the more recent plants at Company B,<sup>6</sup> it is partly the foundation of this Verbund structure, because it produces the basic products that are used in one way or another in most plants on the Company B site, namely ethylene and propylene.<sup>7</sup>

In what follows, we give a short description of the production process. How does a steam cracker work and why is it called a steam cracker?

In essence, a chemical process always is a transformation process, where something is turned into something else. In the case of the steam cracker, naphtha is transformed mainly into ethylene and propylene. The naphtha that has to be 'cracked' is supplied by Tankpark, another plant at Company B. The naphtha Company B uses comes from all over the world, from Kuwait to Algeria and from Spain to Russia. A large part also comes from the refineries in harbour of Antwerp. As we have mentioned before, the steam cracker plays a major role in the Verbund structure of the Company B site. Before they had their own steam cracker, Company B was a customer for ethylene and propylene of Company Ludwigshafen. Now they are a supplier for these products, not only for their own internal market, but also for the external market.

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<sup>5</sup> Besides the site in Antwerp, the Company B group has got a number of integrated plants in Ludwigshafen (Germany), Tarragona (Spain), Geismar (US), Freeport (US), Altamira (Mexico) and Guaratingueta (Brazil). Besides these, Company B is planning or constructing other integrated sites in Kuantan (Malaysia), Mangalore (India) and Nanjing (China).

<sup>6</sup> The construction of the steam cracker started around March 1992, while production started at the end of 1993.

<sup>7</sup> The feedstock they use is mainly naphtha, although LP gas, propane gas, ...can also be cracked. This is what they call a combined cracker, with a gas-liquid feed.

Naphtha is then preheated in a feed preheater. In one of the ten ovens<sup>8</sup> the naphtha is evaporated and after dilution of the naphtha by adding steam, the molecules of the naphtha are cracked.<sup>9</sup> This happens at temperatures up to 850°C. This reaction product, called cracker gas, contains amongst other things hydrogen with some carbon monoxide, carbon dioxide and some sulphur carbon monoxide, methane, C2 (acetylene, ethylene, ethane), C3 (C3-acetylene, propylene, propane), C4, pyrolyse gasoline and pyrolyse fuel oil. The rest of the installation is then used to separate these different components.

After the reaction at a temperature of 850°C, which lasts for about one second, the cracker gas is then cooled down in different steps, in different columns, amongst others by use of oil and water. This oil then absorbs the warmth, the oil is then cooled off in a different system. In a fairly similar way water is used to cool down the mixture.

Then to separate this product mixture, it is being compressed so that it can be distilled or extracted into its different components. This happens in different stages, in a number of columns. It would lead us too far to go into this process too much in detail, but what you end up with is mainly ethylene and propylene, which is produced in quantities of 730,000 ton and 430,000 ton per year respectively. To summarise we can say that by extreme heating or by extreme cooling down, the different molecules of the naphtha are separated and recombined into different combinations.

The transformation process that is going on at the steam cracker is a full-continuous process. This means that production is only halted, when something fundamentally goes wrong, or when there is a planned shut down.<sup>10</sup>

This process can be divided in three different parts, namely a hot, a cold and an auxiliary part. We will explain this further into detail when in our description of the case of competence management. (chapter 4.2)

Maintenance and repair run parallel with production.<sup>11</sup> For instance every sixty days, an oven needs to be decarbonized. To get the naphtha up till a temperature of 850°C, methane is used to fuel the ovens. During this reaction process, the residue forms a deposit inside the tubes. As this residue is a perfect isolator, higher temperatures are needed in the tubes. This means that more energy must be used to reach the same temperatures. From a certain level, these cokes will need to be removed from the oven. This oven cannot be used for about 48 hours.

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<sup>8</sup> A new oven is being built at the moment to increase the capacity.

<sup>9</sup> Because the molecules of the naphtha are being decomposed or 'cracked' using steam, the installation is called a steam cracker.

<sup>10</sup> These planned shut downs occur every five years and last about four weeks. The main reason they shut the production down is because of legal safety regulations that have to be followed. This also allows for maintenance, for the removal of organic residue in the tubes and for the implementation of projects that cannot be run when the steam cracker is fully operative.

<sup>11</sup> This parallelisation allows to combine production with maintenance and repair for some, not all parts of the production process.

But this does not mean that the production process is halted. Since there are ten ovens, one oven can always be cleaned. Although this means a reduction in the production capacity, the production process can still continue, while the others remain operative.

## **4. Discussion of the different cases of organisational learning**

In this section, we will discuss four different cases of organisational learning within Company B. In a first case, we will tell you about the ways in which standard operating procedures are being evaluated and improved by the workers. Here we will try to indicate in what ways these evaluations play a role in organisational learning. In our second case, we have a closer look at the competence management system implemented at Company B. Here, we will show how the complexity of the production process has led to the implementation of a competence management system and how this system can be regarded as an exponent of organisational learning. For our third case, we focus on the organisational structure, where we show that the way work is organised in Company B, provides a structural prerequisite for organisation learning. In our final case, we look at how a recent crisis was handled at the steam cracker and which lessons the organisation drew from this crisis.

### **4.1 Re-evaluation of standard operating procedures**

In the discussion of this case, we will have a closer look at what a standard operating procedure is and what its significance is within the chemical industry. Furthermore, we will discuss the plant manual at the steam cracker as one the ways in which these standard operating procedures can be conceptualised. We will also examine the ways in which workers themselves can make suggestions for improvement.

#### **4.1.1 Standard operating procedure**

We can draw an analogy between the preparation of food in the kitchen and the production of a chemical substance (Huys R. et al., 2001: 32-33). In preparing a meal, you would first of all need all the necessary ingredients. But with these ingredients, it is possible to make a fair amount of different meals. To end up with the dinner you planned to make, you could either mix all the ingredients together and hope for the best, or you could follow a recipe. A recipe is an algorithm, a plan that tells you how the food should be prepared. During the preparation of food, by lifting up the lid of the pan, the cook checks whether every thing is going according to the plan. These are interim measurements. The cook also intervenes, by adjusting the temperature of the stove. These same steps of setting up a plan,

monitoring the process by regular measurements and intervening in the process are also a part of the production of chemical substances. There are of course still big differences between cooking and the production of chemicals, but it shows what a chemical production process is in essence, namely a transformation process of raw materials.

And just like in a recipe, there are procedures in the chemical industry that tell you what to do at a certain stage of the production in order to perform a certain operation in the plant. These standard operating procedures have in common with a recipe that they are both algorithms, which tell you what to do in which order, but in our analogy, the standard operation procedures are not the recipe. Since the steam cracker is a highly automated plant, we can find the recipe in the physical layout of the plant. The standard operating procedures as we understand them are procedures for performing certain tasks to keep the plant operational. Since these tasks are crucial and safety and environmental risks are involved, procedures have been developed to carry out these tasks.

#### 4.1.2 Plant manual

At the steam cracker, these procedures have been written down in a plant manual. In former times, this manual was kept only in written form on paper. Now, this manual is maintained in an electronical form that can be consulted by every worker from a computer terminal.

Originally, the plant manual was drawn up by the engineers of the firm that designed the steam cracker for Company B. But the steam cracker is a dynamic environment. New things are still added to the steam cracker, like for example a new oven is being built at the moment. Such technical changes, which are *planned*, are documented parallel in the handbook with their development, in order to keep the manual up to date.

Next to planned changes, there are also *unplanned* changes in the plant manual. These can occur on a technical level, most of the time when something unforeseen has been changed in the installation. Such unplanned changes in the plant manual almost always happen when something goes wrong. When the plant is running smoothly, it is not always noted that some things could be handled more efficiently.

“Of course when everything is running normally, you don’t notice the problems. You keep your hands of the process and you ... optimise a bit to get more from the process, that yes, but apart from that, nothing happens.” (Interview KDV, 03/04/01: 10)

It is when difficulties arise, that people start to think how it could be better arranged in the future.

“Most of the times, when proposals are submitted, it happens when we have experienced some problems. (...) That is when you see the problems, otherwise you just overlook them.” (Interview JK, 03/04/01: 6)



The plant manual is thus updated regularly. As one of our interviewees put it:

“It is a sort of living book.” (Interview AN, 05/04/01: 9)

Although they keep a printed version of this plant manual, in a strict sense, it is no longer a real book, since it is the electronical variant that is used most widely.<sup>12</sup> At the steam cracker, there is a procedure for updating this handbook, which is fairly similar to making a suggestion for improvement, as we will see in a following part. A workers puts his idea of what could be improved in the handbook down on paper and hands it to his team leader. He reviews this and hands it over to management who also has a look at it and they put it into the handbook.

Not only does this plant manual include the procedures in terms of knowledge, it also includes the transcribed experiences of certain workers with certain disturbances. These notations are put in incident reports.

“When certain people experience a disturbance, they put it in writing afterwards in order to remember it, when a similar incident happens. There are people who do this very individually, who keep that disturbance for themselves. This is a kind of job protection. We try to encourage people to share this information and to draw up a incident report, that then becomes part of the plant manual.” (Interview EDB, 29/03/01: 8)

In this way, the plant manual not only tries to transcribe the knowledge of an operator but also to capture his experience. But in order to use this knowledge and experience which is stored in the plant manual for organisational purposes, and thus for organisational learning, the information which it contains must be easily accessible and retrievable. In other words, you can store as much information as you want, if you haven’t got an efficient way of retrieving this information, this databank of information is quasi useless. So just centralising knowledge and described experiences, is not enough for it to be organisational learning. Just having an organisational memory is not enough for organisational learning. It must also be possible to retrieve this information and to redistribute it among the workers.

As we have stated, the information must be easily accessible and retrievable. The first is certainly the case. A great number of PC’s are available for the workers on which they can access the electronical information system. But (physical) accessibility is not always the same as the retrievability of the information. Some workers find it hard to retrieve certain information in the electronical plant manual. When asked whether the electronical plant manual was easy to use, our respondent replied

“No. (...) But from the moment that some one has got a question (concerning where to find something in the plant manual), we (team management) teach him where to find that information. For someone who doesn’t use the system

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<sup>12</sup> The printed version is only updated a couple of times a year, the electronical variant is updated continuously.

regularly, it is fairly complex to retrieve certain information.” (Interview JK, 03/04/01: 9)

The management of the plant certainly acknowledges this problem. They indicate that improving the existing plant manual is one of their priorities. Several initiatives are being undertaken to make the retrieval of information a less complex matter. One of the problems with the plant manual is that the text included is continuous, and that up till now, new additions to certain sections in the plant manual were added without placing subtitles or something similar. This makes it hard after a certain time to retrieve certain information. This is going to change in the future. Instead of continuous text, subparagraphs and subtitles will be used which can be included in the table of contents.

So improvements to the plant manual are possible and are also being made. With an electronical plant manual, the management of the steam cracker possesses a strong instrument for organisational learning, if it is used in right way.

### 4.1.3 Suggestions for improvement

The workers themselves can also add new knowledge to the plant manual by making suggestions for improvement, which can be taken up in the manual. The procedures are thus not entirely fixed, they can be altered, also by the workers. But the workers cannot change these procedures themselves.

#### 4.1.3.1 *Individual suggestions*

To change a procedure, the workers have to follow a certain procedure. To this end the steam cracker has a 'suggestion committee' at their disposal. Ideas for improvement that are specific for the steam cracker go through this suggestion committee. When a worker notices something that can be improved with regards to safety, quality, production output, environmental issues, be it the procedures or some technical aspect, he can fill in an 'improvement form', where he explains what and why something should be changed. This improvement form is then transmitted via the team leader to the suggestion committee. This committee consists out of a representative from the plant management, one of the foremen and someone from the technical departments and a representative for production. Here, these suggestions are then discussed. If these suggestions are approved (not necessarily executed), the person gets a financial reward. Such suggestions can be made by all workers, independent of their level.

#### 4.1.3.2 *Group suggestions*

Of course, such a system of individual rewards for individual ideas is not always beneficial for the quality of an idea. A competitive atmosphere can arise where each person tries to guard his own ideas and doesn't share them with others in order not to lose the benefits he can reap of his idea. For this reason, they stimulate ideas being worked out by groups of people. Like one team leader told us:

"In principle you can enter an individual proposal and then you get an individual reward. But at a certain time, we were thinking: if I am working on an improvement proposal, which takes up a lot of time, it can be that other people are working for you at that moment. Because you are working on the improvement proposal. (...) It is our intention, and this is also supported by the suggestion committee, to look at the ideas more like a group. A person still often writes the improvement proposals, but this person goes to discuss it with the other people from his team. Sometimes someone of the shift management reads this idea, and then the idea is submitted as an idea by that team. This team also gets the reward." (Interview EDB, 29/03/01: 13-14)

The philosophy behind the group ideas is that a group of people can offer more different perspectives and suggestions on an idea than an individual can on its

own. At the steam cracker, we notice an evolution more towards group proposals. Team management therefore encourages group proposals.

#### 4.1.3.3 *Idea managers*

Other initiatives at a central level are being undertaken to go from individual to group proposals. Central management of Company B is planning to instate what they call 'idea managers'. Next to the rest of their work, these idea managers would then try to stimulate and capture creative ideas from different people and try to elaborate on these in a group. In essence, it is the same as the example above, except that a person is designated who will fulfil an intermediate role for stimulating and bringing together different ideas.

As some one from personnel management of Company B said:

"Among our employees, there is a lot of creativity present in the form of new ideas and experiences. We intend to use these in a consequent and constructive way. By implementing an idea manager, we try to counter the competition between our employees concerning creative ideas. Company B also has got an idea box, but we want to get rid of this philosophy of individual rewards for individual ideas. We intend to grab creative ideas at a plant level and elaborating them, not as an individual, but as a group. It would not become a separate function, but more like a role that someone takes upon him."

This is an example of how the organisation tries to bring all different creative ideas together by having someone gathering all these ideas. Thus an idea manager can be regarded as someone who tries to gather knowledge from different people for organisational purposes. In this way, the institution of such a role can be regarded as organisational learning.

#### 4.1.3.4 *Incident reports*

As stated before, most suggestions happen when something has gone wrong. At such times, it becomes clear what is malfunctioning and which procedures can still be improved. When an incident happens, the workers at the steam cracker are required to write an incident report, of what happened and why. This is then included in the plant manual. These incident reports thus functions as a kind of organisational memory of everything that has gone wrong at the plant.

But besides functioning as an organisational memory, the incident reports often acts as a kind of catalyst for suggestions on improvement. The function of an operator is of that nature that at certain times, he is extremely busy but at most times, he has got almost nothing at hand. An operator has the time to think situations through and reflect on them in order to come to an improvement proposal.

"For reasons of principle, we are obliged to write an incident report, when there is a disturbance. This means, when there is loss of production, when environmental issues are at stake, when someone has been hurt. In such extreme

cases, an incident report is always written. These are electronically stored and can be looked upon from time to time.” (Interview EDB, 29/03/01: 8)

#### 4.1.3.6 *Grey booklet*

At the steam cracker, workers have the practice of writing certain things down in a kind of little *grey booklet*. Most workers have a different notebook for every section of the installation (hot, cold and auxiliary) and carry these around with them when they work in a specific part.

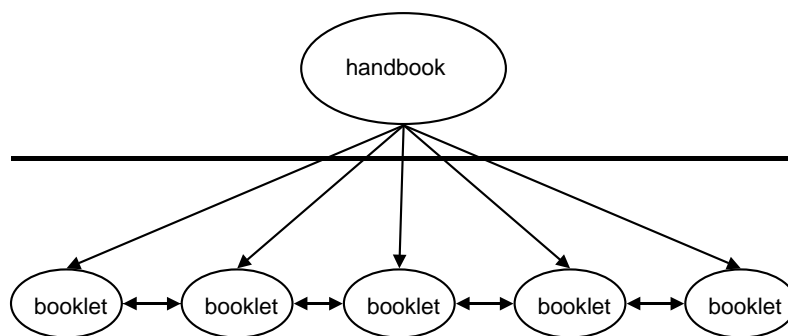
“We also have a booklet of our own, for outside and for inside. In these, we write everything that we get passed through from our colleagues. I have learnt this practice from a control room operator, who had such a book. I have taken his book for a while and copied it and added my own things. I have got such a booklet for each different part inside and outside. When I don’t know how to perform a ‘hot start’ for example, I look in my booklet and see that I have to follow six steps. An other example is how to decoke an oven, described in our own words. You also find this in the plant manual, but having this booklet makes it easier, since you have written it yourself.” (Interview FVDB, 03/04/01: 7)

Most of the information that is included in the grey books, can also be found in the handbook. But sometimes when something goes wrong, it is crucial to have instant access to certain information. And experienced workers especially know what information is important to include in these booklets. This information is then written down in a condensed form in such a booklet.

When a newcomer arrives, he gets assigned a godfather, who shows him around and who also lends him his copy of this grey book, so that the newcomer can make a copy of this information in a booklet of his own. In this way experiences of workers, of what is important to know, are transferred.

This is an informal practice, which does not originate from the plant management. And although it is an informal practice, there is a kind of a structure present to stimulate the transfer of knowledge in these booklets by means of a godfather system. This practice is common (and we assume specific) for all operators, working in the Antwerp harbour. Although it is a practice of individual learning, it contains aspects of organisational learning. Workers don't all have to gather the information included in such a booklet for themselves. When a new worker starts, this information is swapped between the workers and the experiences in them are thus transferred. From this viewpoint, we could say that it indeed bears aspects of organisational learning, which are not steered by the organisation.

But certainly one element of organisational learning is missing, being that there is no institutionalisation of information. The information is not centrally objectified which means that the information does not flow back to the organisation as such.



**Figure 3.** Asymmetric information flow between handbook and booklets

There is a direct information flow from the handbook to these little grey booklets. This information is then distributed among the workers by exchanging booklets. But on the other hand, there is no direct information flow from these booklets back to an important element of the organisational memory, namely the handbook. Thus because of this asymmetric information flow, we cannot call this interesting practice a case of organisational learning, although at first glance it does certainly bear several aspects of organisational learning.

In relation to this asymmetric information flow, we can ask ourselves who does benefit from organisational learning? Maybe the workers do this out of a worry to become obsolete. They want to have the feeling that they can keep some knowledge for their own. And because the management knows that what is written in these booklets is almost all included in the handbook, they allow this practice to continue, giving the workers the illusion of having a certain amount of control over their knowledge. But an operator at the steam cracker doesn't need to worry about his function disappearing. For the company, it is foremost his experience with disturbances that is of importance, and since it is much harder to

institutionalise this experience, then it is to capture his knowledge. Because of the highly complex layout of the process and of the importance of the experience of an operator, his function may be redefined in the future, but it will certainly not disappear in the near future.

#### 4.1.4 Link with organisational learning?

Here, we will have a look at the way the different initiatives can be linked to the five criteria of organisational learning which have been drawn up by the research consortium. All these initiatives have to be seen in relationship to each other. Not scoring well on all five criteria does not mean that an initiative isn't a case of organisational learning. Because of the interrelationship of all initiatives, they have to be regarded as elements of one case

The use of an electronical *plant manual* adheres to criterion two and criterion five of our criteria, because this plant manual is an important tool for learning and for the transfer of knowledge within the plant.

The *suggestion system* and the *ideamanagers* comply with all five criteria, because as a result of these initiatives, work routines are being evaluated and altered, informal learning is stimulated; the three different cultures of the operators, the engineers and the executives are confronted and their different visions are presented and questioned; knowledge is created and shared and there is also learning from the environment. A newcomer, regarded here as someone from the environment can make very good suggestions on practices that people who have been working there for years take for granted. Numerous workers of the technical department gave us several examples of this. And the ideamanagers bring people and ideas together from different plants, which otherwise would have never met.<sup>13</sup>

The *incident report* meets three criteria. Work routines are being evaluated in these reports, learning is being stimulated by thinking of better ways of doing things<sup>14</sup> and since they are put into the electronical handbook, all this knowledge is shared within the entire plant. (criterion 1,2 and 4)

Although we cannot qualify the *booklets* as a means of organisational learning, because of the missing link of this initiative back to the organisation, certain criteria are certainly met by this initiative, and therefore we include it. Because each new worker is assigned a godfather who helps him during the first few months, there is a structure in place that stimulates informal learning. This godfather also lends the newcomer his booklet, so that the newcomer can learn from this and make a copy of his own. Thus a learning culture can grow, because all this knowledge is transferred between the workers. (criterion 4)

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<sup>13</sup> Whether another plant of Company B belongs to the environment, depends on the viewpoint adhered. Since our unit of analysis is one specific plant, we can regard other plants/departments of company B as belonging to the environment of the steam cracker.

<sup>14</sup> These suggestions will hopefully end up in the handbook by means of the suggestions system.



## 4.2 Competence management

In order to understand how the competence management system at Company B works, we first need to understand which functions are essential for the chemical industry in general and for the steam cracker more specifically. Three tasks have to be performed in order to keep the plant running, namely the task of an operator (inside and outside), the maintenance of the plant and the analysis of the quality of the product. Together with the tasks of management, these three tasks are essential for keeping the steam cracker, or any other chemical plant running.

The labour force in a plant like the steam cracker is rather limited. The steam cracker can be operated with a minimal occupancy of fourteen operators. With these people, the plant can be handled in case of a serious disturbance. Not included in these fourteen people are the maintenance personnel nor the quality analysis personnel, because technically speaking, they provide services to the steam cracker, and these services are provided by separate divisions within Company B.

However, in what follows we will also include these tasks into our presentation of the tasks at hand, because all these tasks are mutually interrelated.

### 4.2.1 Operators

We can make a distinction between the job responsibilities of a control room operator and the responsibilities of a field operator. At the steam cracker, every worker is trained to be able to perform both.

#### 4.2.1.1 Control room operator

*Preparatory tasks* for a control room operator are fairly unexistant, since he takes over the previous shift. At the steam cracker, this shift transfer happens in two different steps. The team leader goes through the shift report that has been drawn up by the previous team leader on shift, and he briefs his workers. During a second phase, these workers then go and sit at the console where they will work that day (hot, cold, and auxiliary) and discuss what has happened during the previous shift with the responsible operator of the previous shift. Dependent on what happened, there can be documents the operator has to consult at the beginning of a shift. (e.g. incident reports, shift reports, updates on the plant manual,...) Although these tasks are essential, certainly for the transfer of information, the contribution of these tasks to his entire job responsibility is fairly limited and by its nature routinely. But these preparatory tasks can influence the way and order in which the operator performs his *executing tasks*.

These latter tasks can differ very much dependent on the condition of the process. When the process is stable, or when the operator assumes the process is

stable, these tasks include controlling, regulating, optimising and starting and shutting down the steam cracker.

*Controlling* is essential, because neither the automatic alarm system, nor the measurement equipment can be trusted automatically. As these systems can fail, the operator functions as a kind of back-up for these failures. When the measurement equipment fails, this can mean two things. Either the instrument does not record deviation anymore and errors have then got to be reported by the field operator. This is why at the steam cracker, the field operators also take measurements when they go outside to check the installation in order to counter-check the measurement in the control room. Or an instrument can also give the wrong information. This is where the experience of a control room operator is crucial. If he takes the wrong decisions, based on this information, serious incidents could happen, as one of the workers mentioned.

"The optimiser didn't work today. I hadn't found a message why, but the targets he gave were impossible values of ten thousand. This is obviously not correct. I went to my boss and told him. He said: 'Luckily, you didn't start that'. Because then problems could really have been seriously big. You know, all these things do work, but you have to pay serious attention, otherwise things can get out of hand." (Interview AN, 05/04/2001: 3)

Controlling can also involve anticipating on alarms, in order to prevent errors. When a parameter rises from day to day, an operator can extrapolate this and take preventive action.

"Sometimes, the filter of a pump needs to be scrapped. And when the pressure of that filter is high, you can follow this up. That it is rising gently. This then needs to be scrapped, to lower the pressure, and when this has not yet been done, you can see this, systematically." (Interview, GVC, 05/04/01: 3)

The order, the time and the frequency of these routines depend of course on the stability of the process, but also on the way these routine checks have been taught to the worker. The way in which these routine checks have been taught can depend from person to person, but in general, there is a fair amount of uniformity in the way these checks are handled during a stable situation.

"There are more people who have done it this way. I have been taught to do it this way." (Interview AN, 12/04/01: 2)

When the value of a parameter will go outside the specifications if left untouched, the operator has to *intervene*. If this doesn't happen automatically, he has to be able to analyse the problem in order to assess the ways in which this problem can be solved. He then has to decide on the way the problem will be solved. There are some rules of thumb he can use, but most of the time, these rules of thumb are too rigid in order to grasp the complexity and interconnectedness of the problems. That is where his experience as an operator comes into play. Most of the time, a problem can be solved in more than one way. From his understanding of the interconnectedness of the process, he can then take the best decision from this experience.

“Different temperatures are not all right, how does that come? If I do this to get the specifications all right, how does it come that this lowers then? It is a constant cat and mouse game.” (Interview AN, 05/04/2001: 3)

So having knowledge of the process and experience with the results of interventions go hand in hand in an operator task. The 'procesverstehen' is thus an important element of what a good operator has to know. Since the steam cracker already is a very complex plant, it is hard to acquire this understanding of the process, which takes up a lot of time. The interconnectedness of the process is also the reason why operators are trained to perform several jobs. In this way, 'Procesverstehen' is also acquired. Ideally, everyone learns the entire installation inside and outside, in order to be able to work in all section but also to have an understanding of what happens in one section if something else changes in a different section.

In the near future, this acquirement of the Procesverstehen will even become more complex, since there are plans to install an '*optimiser*' at the steam cracker. What is optimising, what does an optimiser do and which effects will this have on individual and organisational learning? Optimising goes beyond simply intervening in order to keep the process within the predetermined parameters. Optimising means changing the setpoints themselves in order to obtain an optimal production result.

In the highly automated working environment of the steam cracker, there are four controlling and steering levels. First, there is manual control. All the controlling and steering is done by hand. This is a typical situation during a start-up. A second layer is basic control. A third layer is advanced control. Advanced control is designed to counterbalance disturbances. Most of the steering happens automatically, except when the disturbance is of such a nature that certain parameters go beyond the boundaries of the model. At this point advanced control shuts itself down, and is reverted back to basic control. A fourth level, that has not yet been implemented on-line at the steam cracker, is the optimiser. This optimiser takes a lot more into account than advanced control in determining how the process should be optimised. Once the optimiser is implemented on line, this optimisation process will then function automatically, without any steering from the operators. For the moment, this optimiser is only working off line. This means that the optimiser calculated the optimal targets for certain pressures, purities, ..., and the operator still steers towards these optimal targets using advanced control.

One of the most important tasks of an operator is to respond effectively and efficiently in case of a *disturbance*. From this viewpoint, it is understandable that one of the notorious quotes of plant management is that 'they are happy when their operators are not working, because this means that the process is running smoothly'. And for overcoming such a disturbance, having a good understanding of the entire process in its complexity is essential.

But by implementing this optimiser, it will only become more difficult for a newcomer to learn the intricacies of the plant. First of all because he no longer trains this 'feeling' for optimising on the board, as this function is automatically done by the optimiser. But also because the link between what you do at the board and what happens inside the plant will become less transparent. The 'how'

and the 'why' of this automation no longer comes into view for the operator. And it is just this understanding of the 'how' and the 'why', of the complexity of the process that enables to successfully handle a disturbance. This thus results in the automation paradox.

The more automated a plant becomes, the less experience an operator can acquire in order to handle a disturbance. More automation, especially in an already complex working environment as the steam cracker, poses a potential threat to the entire plant. When the workers loose the feeling for the steering of the process, how will they be able to respond to a disturbance? We will elaborate this problem further in detail when we discuss the handling of critical incidents.

*Starting and stopping the process* is also one of the tasks a control room operator has to master. Planned shut-downs and subsequent start-ups occur every five years at the steam cracker. This is done to perform maintenance tasks that cannot be performed in a running company, and out of safety precautions.

"The main reason is that we are legally forced to do so. We have got devices that work on steam, that have to be inspected. Therefore European Standards have been devised." (Interview NB, 28/02/01: 10)

Next to planned shut-downs, there are also unplanned (partial) shut-downs, like the one in March 2001. We will have a further look at this incident when we tackle the case of the handling of critical incidents. The operator regards a disturbance or a shut-down as an exciting time. When the process is running smoothly and stable, monotony can occur. But this is not the monotony of the (same) act, it is the monotony of the non act. As long as the process is running smoothly, it looks as if operators are hardly working. They look at a screen, drink some coffee and talk to their colleagues. As stated before, a plant manager is happy when his operators are not 'working', because this means that the process is running the way it is supposed to be.

But this situation can change in an instant. At every single moment something can go wrong and for these moments, the operators have to be prepared.

"Sometimes you have too little to do, and five minutes later too much. Sometimes a lot happens at the same time, and then you are short of hands!" (Interview SB, 05/04/01: 8)

For an operator, this can create fairly stressful situations, since they have little control over the timing of a disturbance and it can happen at every instant. Since they have to be prepared to intervene at all time, their 'free time' cannot all be filled up with different tasks.

#### 4.2.1.2 *Field operators*

A field operator at the steam cracker is responsible for the well-functioning of the physical installation outside. He works in the production installation itself and checks all the equipment outside. For this, he works in close contact with the control room operator in two different ways.

First of all, he can *inform the control room operator of defects* in the installation he discovered during one of the controlling tours. At the steam cracker, predetermined routes through the installation have been drawn up. In total eight different routes are possible, which cover the installation in its entirety. When a field operator does one of these routes, he takes with him a handheld computer, the size of a mobile phone. This computer asks for certain checkpoints for each route, which the field operator fills in. This helps to take him through the process and provides extra information about the process. This also forces the field operator to pass everywhere to make sure everything is all right. As one of the field operators mentioned:

“You have to fill in a certain number, but you are also supposed to check whether everything around is ok. When there is a temperature meter which indicates a hundred degrees, but besides it, there is a leaking pipe, you are also supposed to notice this.” (Interview, GVC: 2-3)

And automatic measurements inside the control room cannot replace the experience and the sensory perceptions of a field operator who walks through the installation. Although the inspection rounds are predetermined, the interpretation of a field operator of his perceptions, smells, sounds, his ‘feeling’ for the process remain crucial.

“When I show a new person around, I always say what and why I do something. Then you always let this person feel (a pipe) for himself or have a listen (at the sound a valve or a pipe is making). And this experience cannot be written down in a book, I think. That is different every time and subject to different ways of interpreting. You can’t say that a pipe is flown through, when... For instance, you open a valve very gently. If there is warmth on both sides of the valve, you could say that there is circulation, but that is not always the case. For instance when you expand a fluid to a gas, it cools off. It could become colder, it could become warmer. That is something very specific that you cannot summarise like that.” (Interview GVC: 8-9)

And even in predetermined, pre-set routinized tours, the field operators sometimes bring in their own creativity by passing by all measurement points of a route via a different way. As one of the operators told us:

“These tours, you can do them blindfolded. If you do them just for the meters, they are purely routine. You try to bring in some variation by taking another way, or by paying attention to something specific. Although the handheld computer prescribes a certain route, you write the measurements on a piece of paper and you fill them in later.”

When a field operator notices a disturbance, he informs the control room operator. What a disturbance is, can also be learned from experience, which is transferred from field operator to field operator.

“If things happen that are not normal, we report them immediately. For small things, like a pump that makes a lot of noise, ... if we don’t find it alarming, we are not going to call up someone immediately. A water or a steam leak is not

crucial. We report everything that has caught our eye and then action is being undertaken. (...) You learn from experience what is of importance and what not.” (Interview GVC: 3-4)

Second, the *control room operator can also ask that the field operator checks an anomaly in order to locate and identify errors*. The control room operator can also give instructions to the field operator to make certain manual adjustments in the field like manually shutting down or starting engines or by-passing defunct machines. Because the control room operator has an overview of the entire process, he is the one who controls the process and if necessary, intervenes.

#### 4.2.2 Organisation of labour at the steam cracker

For the entirety of the workforce at Company B, competence profiles have been drawn up at the central level, as a kind of guideline for evaluation and development. The competencies for a worker are fairly broad defined. They entail the ability to co-operate, the commitment and the employability of a worker, his eye for Quality, Safety and Environment and for Integral Quality Care, his sense for innovation and change, his abilities for co-ordinating and guidance and finally his professional skill. These competencies are broadly defined, since they have to apply for the whole of Company B.

Each plant uses these guidelines to formulate plant specific competence profiles. At the steam cracker a system of job descriptions is used that fits within these competence profiles, ranging from Aa to G.

Table three shows us how it is used at the steam cracker. This table contains a lot of information about the way the work at the steam cracker is organised. In the part that follows, we will explain this table into detail.

**Table 3.** Plant structure of BB/S

Maximum number	Job numbers			Minimal occupation
	1	2, 3	4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	
1	G			
2	F	F		1
2		E	E	2
17			Bb-Cc	11
= 22				= 14

Source: Company B steam cracker, internal document



#### 4.2.2.1 *White-collar workers*

Since the nature of the production at the steam cracker is a continuous flow, a shift system has been devised. There are four different teams. The structure of each team of workers at the steam cracker is identical, so in what follows, a description of one of these teams will be presented.

At the steam cracker, each team has one team leader. Table 3 shows the number for this job is one. What are the competencies required for the job of team leader?

Firstly, he is responsible for the co-ordination of work in general. More specifically for the steam cracker, this means that he is responsible for the shift reports and the transfer between the shifts, for the quality of the raw materials and the products, for the well-being of his workers, for the environment and for the tidiness of the workplace. Secondly, he maintains an overview of the process and the work-in-progress. Thirdly, he has also got to prepare the instructions. Furthermore, he carries the responsibility for his workforce. He takes care of the staffing, the following-up of the training of his workers and he organises the evaluation discussions of his workers.

Table°3 shows that someone who is of a G- or F level can do the job of team leader.<sup>15</sup> The difference between these two functions lies in an extra responsibility for the person of G-level. He is responsible for the overall policy within the team. The person who is of G-level is then the team leader, the persons who are of F-level can replace him, when he is not there. One of the two persons who is of F-level is assigned to be the assistant team leader.

Between these two categories, F and G, there is a one-out-of-two rule. One of those people in these two categories has got to be there, to act as team leader.

For each team, there are two chief operators. These correspond to job numbers two and three in table 3. The installation of the steam cracker is divided into three different parts, a hot part, a cold part and an auxiliary part. One of the chief operators is responsible for the co-ordination of work, process control and optimisation in the warm and in the auxiliary part. The other chief operator then has got a similar responsibility for the cold part of the installation.

During the interviews, it was being stressed that these two chief operators don't work independently but that they co-operate. This shouldn't be looked upon as two different teams working side by side. It is the team leader who integrates jobs that are of importance to both chief operators, because everything that happens in one part of the installations can be of influence on another part of the installation. Because of this interdependence, people working in the different parts have to work as one team.

Someone who is of F or of E-level can do the job of chief operator. Someone of E-level must first of all be able to apply plant specific quality-, well-being- and environmental instructions. Second of all he must be able to conduct evaluation

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<sup>15</sup> The letters used here refer to the competence profiles as they have been drawn up at the steam cracker.

discussions with his workers. The difference between someone who is of E- and of F-level is that the person who is of F-level must have the abilities to replace the team leader, and must be able to draw up a good qualitative and quantitative occupancy of the team.

Looking at the categories reviewed thus far, they range from E to G. The persons within these categories all have the statute of white-collar worker. In our table<sup>16</sup> above, we can see that there is only one person of G-level, two of F-level and two persons of E-level. These five people make up the shift management. For the shift management, there is a three-out-of-five rule. This means that of these people, at least one team leader and two chief operators have to be present at the steam cracker at all time.<sup>16</sup>

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<sup>16</sup> Several combinations of minimal occupation are possible:

- 1 G (team leader), 1 F (head operator), 1 F (head operator);
- 1 G (team leader), 1 F (head operator), 1 E (head operator);
- 1 G (team leader), 1 E (head operator), 1 E (head operator);
- 1 F (assistant team leader), 1 F (head operator), 1 E (head operator);
- 1 F (assistant team leader), 1 E (head operator), 1 E (head operator).

This three-out-of-five rule is possible, because everyone at the plant is trained towards knowing the entire process. For example, when looking at the job description of a person of an E- or F-level, you don't find an E-level person, trained for the hot part alone, or for the cold part alone. Someone of E-level has got to know it all.

#### 4.2.2.2 *Blue-collar workers*

If we again take a look at the table above, we see that there are still eleven job descriptions left about which we have not yet spoken. In a minimal occupancy situation, there must be at least five control room operators and six field operators.

A team leader, two head operators and eleven operators can run the entire steam cracker. If we look at the different sections of the steam cracker, we notice that for the hot part, there is one control room operators, for the cold part there are two. For the auxiliary part, there is only one control room operator. It is their responsibility to co-ordinate the steering of the process at the board in the control room and to have the necessary samples taken and analysed.

Furthermore there are two field operators for the hot part, two for the cold part and one for the auxiliary part. They co-ordinate the activities outside in their part of the installation in close consultation with the person responsible for the process steering inside the control room of that part.

The operator functions are filled by people who are either Bb, B, C or Cc by category. Basically, the main difference between these categories lies in the knowledge of certain parts of the installation inside and outside.

People at the B-level are required "to have knowledge of a certain part of the installation outside. This also implies that they must be able to operate this part of the installation independently when they have been given instruction." (Internal note Company B) It is up to their own personal preference, in which of the three parts of the installation they start.

The Bb-category is the next category a worker can promote to. Here the person has to make a choice whether to learn another part outside, or to get to know the part they already know outside in the control room. This means that people in this category "must have knowledge of and be able to operate two parts of the installation outside (hot and cold, hot and auxiliary or cold and auxiliary) or they must have knowledge and be able to operate one part of the installation outside (hot, cold or auxiliary) and have knowledge and process steering capabilities of a part of the process steering system, so that they can work independently as the second man at this console." (Internal note Company B)

The following category is the C-category. Someone of C-level "must have knowledge of and be able to operate the entire plant outside (hot and cold and auxiliary) or must have knowledge of and be able to operate two parts of the installation outside and be able to steer the process from the console in the control

room (hot and cold, hot and auxiliary, cold and auxiliary). Furthermore, this person has to be able to draw up a shift report and complete a good shift transfer. Besides having global knowledge of all plant specific quality-, well-being-, and environmental instructions, this person must have detailed knowledge of the concerned quality-, well-being- and environmental instructions. This person must also be able to apply this knowledge. Finally, this person must also have detailed knowledge of all security systems and of all permits at the steam cracker.” (Internal note Company B)

The final category of workers is the Cc-category. Some one who reaches this level “must have knowledge of and be able to operate the entire installation outside and inside at all three consoles (hot, cold and auxiliary).” (Internal note Company B)

The categories as they have been presented here are cumulative categories. As we have seen, the category of workers goes up to Cc. It is the policy of the steam cracker that everybody who starts here, can reach this level.

“Not everybody will become Cc, but everybody can become Cc if they have got the competencies as they are being described.” (Interview NB, 15)

There is a great deal of flexibility built in the way a person can learn the plant. Workers have the freedom to choose which parts they want to learn outside and/or inside and in which order they want to learn them. This competence system is organised in such a modular way, that everyone can get to know the whole production process of the steam cracker following the distinction outside/inside and hot/cold/auxiliary.

And although there are some restrictions, like first learning a part outside and then inside, this flexibility gives the worker great control over the way he plans his career. Also, not everyone has got the ambition to become Cc. Some workers prefer only to work inside or outside, or only in a certain part. And although the training at the steam cracker is aimed at stimulating polyvalence, this is also possible

But there are also some boundaries to this flexibility. We have seen that for all the categories, certain competencies have been drawn up. And in order to get to a higher category, these competencies have to be acquired. But not only is there a link between the category and the competencies, there is also a direct link between the category acquired and the wage received. You get an increase in your wage, when you have acquired the competencies of a higher category, and when you are actually promoted to this category. And although newcomers can opt to start in any of the three sections, most of them start in the hot section, as one of our interviewees pointed out.

“Most of the time, people start with the ovens, because they are ten times the same, so in the hot part. Certainly for a new one, because it wouldn’t be serious to let him start in the cold part. That is fairly complex and it takes a while to get to know it thoroughly enough to get a raise. In the hot part, you can do it in one

year, and have enough knowledge about it to be eligible to get a raise. For the cold part, that takes at least two years, two years and a half.” (Interview GVC: 8)

Since some competencies are more easily acquired than others, in this case the technical competence of getting to know the hot section, the flexibility the workers have when they start, is bounded by practice. This bounded flexibility is not necessarily a bad thing. Since newcomers start in an easier section, they will probably not be overwhelmed by the complexity of the entire process.

Another restriction on the freedom of choice, can be the acquired level of the other workers in your team. This is dependent on the policy the team leader has implemented in his team. It is possible that he asks first to learn a certain part, because he needs more people in his shift to occupy a certain position.

“A person who is new at the plant has to follow a number of courses. Afterwards we haven’t got a procedure where this man has got to develop according to the following steps in the following year. It depends on whether this man first learns the hot or the cold part. But some teams require that first the hot part should be learned outside and inside.” (Interview FW, 05/04/2001: 6)

In terms of the work, a distinction is made between a control room operator and a field operator. In the competence profile, however, this distinction is not explicitly made. There is no separate competence profile drawn up for a field operator or for a control room operator. Everyone is trained towards polyvalence, towards knowing everything outside as inside. In the end, everybody can become Cc.

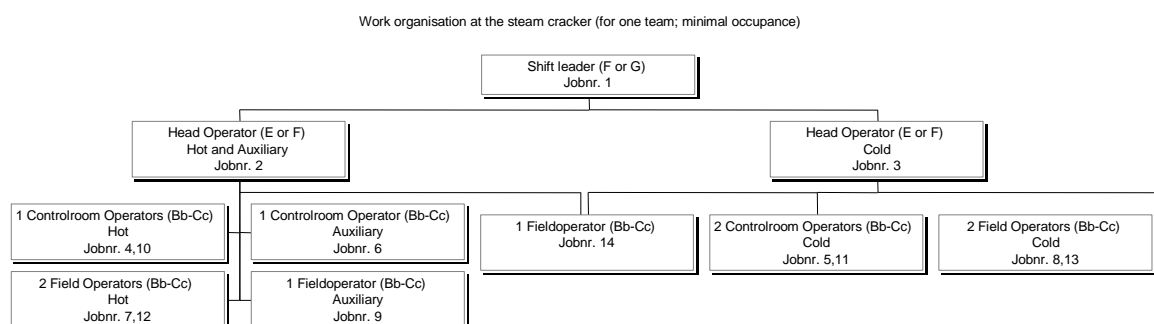
There are two more categories that haven’t been mentioned yet, namely the Aa- and the D-category.

The Aa-category is the category in which a newcomer starts at the steam cracker if he hasn’t got any previous experience in a chemical plant. A list is available of things this worker has to know after two months, six months and twelve months. Someone who is of Aa-level is not counted as a member of the team occupancy. It is only from level B on that a worker is regarded as employable.

The D-category is a kind of intermediate category for those who are Cc and in who the plant management sees the potential to become a member of the shift management. Not everybody gets the opportunity to become a member of the shift management. First of all, there has to be a vacancy to become of E, F or G level. Second of all, you have to be chosen by the shift management.

There is also one job number left of which we have not spoken yet, namely job number fourteen. This person acts as an extra field worker who can be assigned to do work in all three parts.

It is now possible to convert some of the information available in table 3, into an organisation chart, that sums up what we have mentioned before.



**Figure 4.** Work organisation at the steam cracker

The situation as described here, is the minimal occupancy situation in one shift. It is possible that at one time, more than eleven people are working in one team. There is a maximum number of seventeen workers at the plant. Add to this the five members of the shift management. Thus, we become a total number of twenty-two team members.

This is in short the competence management system as it is used at Company B. Management keeps track of who has got what competencies by means of an electronic registration system. Since this is a highly transparent system, which everyone can access, only technical skills are kept track of.

#### 4.2.3 Pitfalls

The role of the team leader is of great importance for evaluating the competencies a worker has acquired. For promotions, a yearly planning is drawn up for every individual by the plant management. The plant manager then takes the decision about a promotion in close consultation with the team leader. Although the end responsibility for a promotion is attributed to the plant manager, the vision of the team leader is predominant, since he knows his team members better from every day work and can assess their qualities better.

For education and training, the team leader has the sole responsibility. This is handled, by the team leaders own discretion, independent of the management. As the plant manager told us:

“He knows the best what everyone can do and what still is needed in terms of training, this I leave totally up to him.” (Interview FW, 05/04/01: 4)

Training and promotion cannot be looked upon independently. Acquiring competencies is a prerequisite for promotion and competencies can only be acquired by some form of training. Although training and education is the sole responsibility of the team leader, plant management is indirectly also in control of the training in the teams by drawing up a yearly promotion planning for each individual worker.

But this control is still an indirect kind of control. Each of the four team leaders can still shape the way he sees training and education within his team independently of the other team leaders or of management. As a result, there are fairly large differences in the ways the different team leaders handle their team specific training. Idealtypically, a distinction can be made between two different approaches, what we call the ‘knowledge-oriented’ approach and the ‘experience-oriented’ approach.

Imagine two newcomers who start at the steam cracker. One starts in a ‘knowledge-oriented team’ and the other one starts in a ‘experience-oriented team’. The first type of team is very oriented on following the procedure to the letter and on the acquisition of knowledge. The management of this team requires that this person goes through the plant manual first, that he can answer certain questions about a certain part of the plant, that he has coloured in the outline

schemes of the steam cracker, that he has studied the process schemes and that he can draw the pipes and the pumps, ... This type of team will first go through the entire procedure and will try to transfer the knowledge in a very strict, predetermined way. The other person, who starts in the more 'experience-oriented' team, will be taken outside by one of the experienced workers and they will for instance start a pump. Not much paper work will be drawn up and the training will be more informal. While the other type of team is oriented more toward the book knowledge, this type of team prefers on-the job training and learning through the transfer of experience. They will go round the plant to see what goes through that pump and where it comes from. And although this type of team also follows the procedures, their orientation towards them isn't that formalistic.

So in essence there are two types of handling training at the steam cracker. There also seems to be a close connection between the type of team and the performance in handling disturbances. Overall, these two types of team perform equal, but the type of team that put the transfer of experience up front is performance wise slightly better in handling a disturbance than the type of team that is oriented towards book knowledge.

That the teams differ from each other where education is concerned can for a part be better understood if we bring in a historical perspective.

"It is still a heritage we have of ten, twenty years ago, when Company B was a collection of independent companies where every company was a kingdom of his own." (Interview FW, 05/04/01: 7)

In the plants of those days, the plant manager and the team leaders held absolute sway over the plant and over the teams. These different team leaders all went their own way, without much interference from outside. So without much outside control, large differences arose between different teams.

At the site level, Company B is now trying to create more uniformity, but the team leaders present today, are all people who started ten to twenty years ago and they still have got the bias from earlier days that they can run their own team according to their own vision. This vision has through the years often become a part of the subculture of a team in which each newcomer is socialised.

Numerous definitions can be given of what culture is, but in our research, we have opted for the definition of Schein. He defines culture as "a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be taught to new members as the correct way of perceive, think and feel in relation to these problems." (Nonaka & Takeuchi, 1997: 58)

The culture of an organisation can be looked at from different levels, the culture of an organisation as a whole, the culture of a plant, the culture of a group of people, etc. When we look at the culture of a team, we have opted to call this a subculture, since this subculture still has part in the overall culture of the organisation.



Such a subculture of a team can become part of the identity of a team, which the team is not willing to change, since for example changing how the education is handled would be a fundamental change in the identity of a team and could lead to an identity crisis of a team. According to this viewpoint, the way education is handled in a team, can be regarded as a shared basic assumption that is perceived as the only correct way within this team. In this way, the teams could see trying to get more uniformity between the different teams by implementing changes from outside, as an infringement on their identity.

How does the plant management try to get more uniformity between the different teams concerning the way education is handled? A few initiatives have been undertaken by the plant management to try to get more uniformity in the way training is handled.

Each year, the plant manager has four meetings with all his team leaders, on which he addresses certain actual topics. One of the topics that was discussed at the most recent meeting was the difference in training in the teams. The plant manager brings his team leaders together in order to come to an understanding between the different team leaders. Another way in which the plant management tries to bring the four teams closer together in terms of education, is by the implementation of an uniform, easy to use, way of registering which training have been followed by which person.

Another initiative to bring the more then fifty different plants closer together was taken at site level by the implementation of the Quality-Wellbeing and Environment-system. These are guidelines regarding quality, well-being and environment that must be followed by every plant. But this initiative is oriented more towards getting the different plants, not just the different teams, in line with a mutually shared Company B culture. (Note that this Quality-Wellbeing-Environmental-philosophy is implemented top down, whereas the culture of a team has grown bottom-up.)

How then could the plant management work within the steam cracker towards getting more uniformity between the different teams? By being aware that cultural change cannot be successfully implemented top down. Since external changes that touch the essence of the culture of a group will not be accepted if they are not supported by this group. So getting the four different team leaders together to discuss their different viewpoints on training and education is certainly a first step in creating a mutual understanding. A suggestion we would like to make, in order to tackle the problem of the diversities in the in-team training, would be to rotate workers between different teams. Several scenarios are possible.

Newcomers of Aa-level, who are not yet counted in shift occupancy, could be rotated between the different teams, before they are assigned to a team. This way, the newcomers who have not yet been immersed in the subculture of one specific team, will become acquainted with the different types of training, of handling problems, of working, ..., with the different cultures of the teams. Since these

workers are not yet counted in the shift occupancy, the problems that could occur by rotating them throughout the different shifts could be limited to a minimum.

This would however have the disadvantage that after this initial period, they would work within the same team, in which culture they would be socialised. So in the long run, uniformity would not yet be realised.

Another scenario that takes this objection into account would be to rotate the workers to another team when they (are about to) receive a promotion towards a higher category. In this way, it would be possible to rotate between different teams and to become accustomed to different ways of working and learning. If you could use such a system together with a well developed individual competence database, which would list the individual competencies of each worker, the teams would become more uniform, knowledge and experience transfer would be augmented and organisational learning would be stimulated.

Since it is within the competence profile of the team leader to take care of staffing and to follow up the education of his workers, he has got a big responsibility for the course of the career of his workers. First of all, he is responsible for the day to day staffing. This means that he has to assign certain people to certain jobs. Within a team, there are rotational rules between jobs, but these differ for each team. The plant management hasn't enforced one general rule. It is up to the responsibility of the team leader to organise his own team. Secondly, he is also responsible for the occupation of the team in the long run. For this reason he is also responsible for the education of his men. He has got to make sure that at all times, there are enough competent men to fill in all the jobs. This can of course mean a restriction on the freedom of a worker to choose which part of the installation he wants to learn next.

"If you look at our registration system for the training, you see that acknowledging that a worker has got a certain competence, happens by the team leader. It is a co-ordinated something between the top five, but as a team leader, he is responsible. (...)." (Interview NB, 28/02/01: 16)

In this way, the team leader, in consultation with the rest of the top five of a team, is of great influence on the course of a workers career. Note that the role of the plant management herein is rather limited. As we were told by the plant management:

"These are things that are organised on a team level and in which we give the team a great freedom. If there is a shortage of good operators, we will notice this too. We do follow this up, but not on a daily basis. It is his (the team leaders) job to do that." (Interview NB, 28/02/01: 16)

Because of his responsibility for a decent long term occupation of his team, he is also responsible for the education and training in his team.

#### 4.2.4 Link to organisational learning

In this case description, we have investigated the function of an operator and at the organisation of labour at the steam cracker. Consequently, we have taken a closer look at the competence management system that has been set up at the steam cracker. Finally, we have addressed some pitfalls. But how is this competence management system related to organisational learning?

We have already brought on the fact that the steam cracker is a highly complex working environment, where it is difficult for an individual to have a complete overview of the entire installation. Furthermore, not all operators need to know the entire plant.<sup>17</sup> So the knowledge of the entire process is divided among the different task performers.

“Our viewpoint is that everyone in a team knows something, and that I alone don’t know everything.” (Interview JK, 03/04/2001: 13)

By means of this competence management system, the management of the steam cracker can monitor whether there is enough knowledge and experience with all the different parts of the steam cracker within each team. This competence management system is thus a learning tool for (the management of) the organisation to keep track of a balanced distribution of experienced and less experienced operators in different teams. In this sense, the ‘organisation’ learns, because if necessary, if the distribution in a team is not balanced, management could possibly intervene in the work routines of a team and try to transform the culture of a team as we have addressed in the section about the pitfalls. But maybe this should better be called organisation learning instead of organisational learning.

Furthermore, although no one is forced to become fully polyvalent, thus to become of Cc-level, the operators are stimulated to get to know the entire installation. Further learning, by getting to know more parts of the installation is encouraged by the coupling of this competence management system with the wage system as described.

Because people with different competencies are mixed in one team, and everyone is encouraged to know the entire process inside and outside, people can learn a lot from each other. This case of competence management matches our first criteria, where work routines in general are monitored. With regard to the second criterion, which is about formal and informal learning, our case also scores well, because of the implicit assumption that everyone can become of Cc-level, and thus polyvalent. Thus learning is stimulated in this way. Furthermore, informal learning is stimulated because of the combination of a godfather system in one team, of a mix of people at different competence levels in one team and of the structure of an operator job, which allows that free time can be used for learning. A similar argumentation can be provided for the fourth criterion, which is about

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<sup>17</sup> Every one can become of Cc-level, but this is not a requirement.

knowledge creation and sharing. This case, as mentioned in the section about the pitfalls, demonstrates the possibilities of using the competence management system to align and transform the culture of the different teams, which complies with the third criterion.

### 4.3 The shaping of the organisational structure of the steam cracker as a facilitator for organisational learning

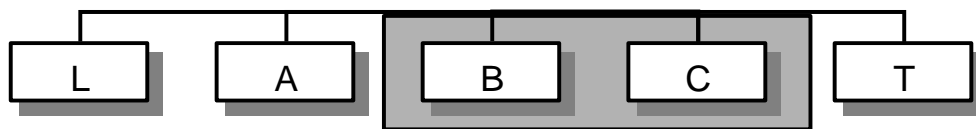
In this case, what we will try to show you is how the way that Company B is organised, affects the organisational learning process. As stated before, organisational learning as it has been defined “implies that the organisation has created a *structure* through which individual learning is permanently stimulated, documented and evaluated.” (Boreham, 2001: 132)

We will show you that the learning that occurs as a cause of this organisational structure is organisational learning, namely that first of all, it is done to achieve organisation purposes, secondly, that it is shared or distributed among members of the organisation and thirdly, that the learning outcomes are embedded in the organisation’s system, structures and culture. (Snyder and Cummings, 1998 as cited in Mariani, M., 2001: 67)

But first, we will have a global look at the way Company B is organised. We will indicate how the steam cracker fits within this picture and how the way in which the organisational structure is filled in, facilitates organisational learning.

#### 4.3.1 Structure of Company B

Understanding the way in which Company B is organised is of great importance for understanding the organisational structure of the steam cracker plant. This is why we here, we present a global overview of Company B.



**Figure 5.** Structure of Company B in five departments

The company of Company B can be divided into four different units. A first unit consists out of the management of Company B as a whole (L). Administration (A) can be considered as a second unit and the technical department (T) as a third unit. Everything that has got anything to do with technical aspects, is handled here. A fourth and final unit of the organisation is made up by production. For the moment, the difference is still made between the two production units B and C. In the near future, this is going to change. We were told by the personnel

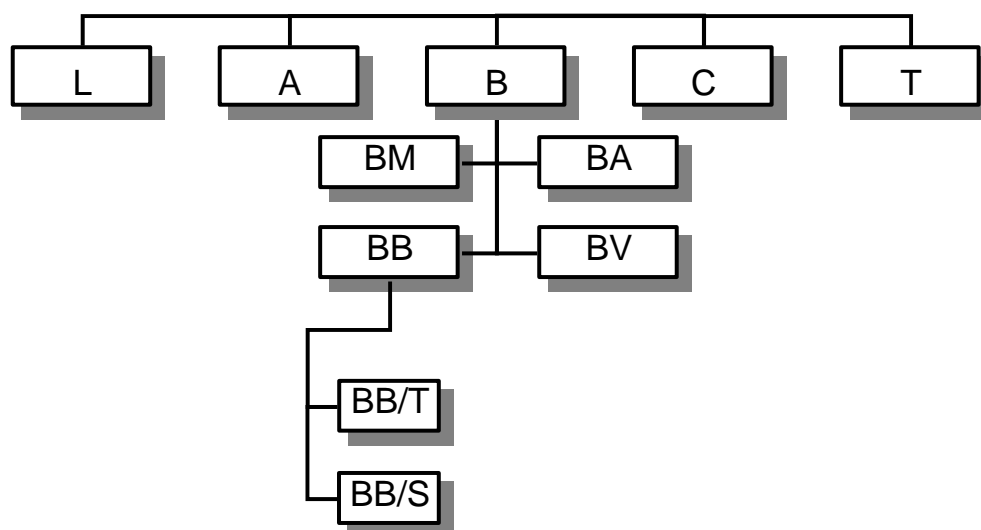
department that Production I (B) and Production II (C), which are now still separated, will then be united into Production (P).

But at the time of our research, this was not yet the case. Company B still consisted out of five different divisions. At the head of each division, we find a director. The different heads of these parts make up the Board of Directors, where as the director of the management of Company B (L) is the Chairman of the Board of Directors.

Within each of these five different divisions, there exist different departments. These different departments are responsible for a core activity of the company and they group services (A, L, T) or production plants (B, C). A head of department is in charge of each of these different departments.

#### 4.3.2 The steam cracker plant within Company B

Within the division of Production 1 (B), we can make a distinction between four different production departments, namely BA (anorganic basechemicals), BB (organic base chemicals), BM (fertilisers) and BV (vinyl – and acrylproducts).

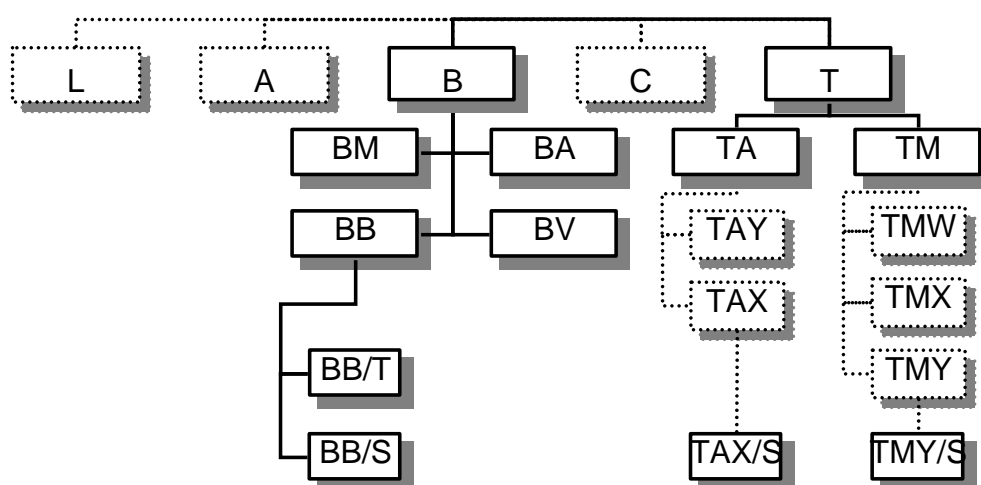


**Figure 6.** Company B, including the departments and plants of B

Each of the other divisions of Company B is also divided into several departments, each with their own heads of department. Within each department of part B and C, we find several production companies, but to list them all here, would take us too far.

The steam cracker (BB/S) is one of the two companies we find in the organic base chemicals-department. The other company is Tankpark (BB/T). Technically speaking, this is the steam cracker as we have referred to it in a previous part, when we discussed the competence management system. In these competence descriptions, no technical maintenance or automation tasks are mentioned. Operators provide little to none technical support for their own plant. Still, a steam cracker cannot function without this support. An operating steam cracker involves not only people from BB/S, but also from the technical division.

Within the technical division, we can make a distinction between two different departments, namely the mechanical maintenance department (TM) and the department responsible for the automation/instrumentation (TA).



**Figure 7.** Company B, departments B and T

Within these two department, several other distinctions can be made, which are not of great importance for our research.<sup>18</sup> What is of importance for our research is that there is one team of people of mechanical maintenance (TMY/S) and one of automation/instrumentation (TAX/S) that provide services solely to the steam cracker.

And because the steam cracker is such a large and important plant, the people from these teams work dedicated to the steam cracker. This means that they don't do the technical support for any of the other plants, that they only work for the steam cracker.

The work organisation in TM and in TA is fairly similar to the work organisation at the steam cracker. At the management level of the steam cracker, which up till now we have not yet discussed, there is first of all the plant manager. His background is that of an engineer. He has got the end responsibility for everything that goes on at the steam cracker.

This plant manager has got six assistant plant managers beneath him, of which three are responsible for one section in the installation (hot, cold or auxiliary). The three others then are responsible for projects and optimisation of the plant.

Furthermore, you have got four foremen, of which three are responsible for each section of the plant (hot, cold and auxiliary) and a fourth one who handles more general problems. These people all work during the day shift.

<sup>18</sup> The X and the Y in TMX, TMY, TAX, TAY used to refer to a geographical division, where companies on the north side of the site would be served by TMX and TAX and companies on the south by the others. But since the size of the Company B site has increased throughout the years and new plants have arisen, this geographical dispersion could no longer be maintained and now both the former geographical divisions provide services throughout the entire site. TMW refers to a central workplace of mechanical maintenance, which TA also uses for central maintenance. Not all the mechanical maintenance work has got to be done at plant level. For instance, pumps whose technology is not specific to just one plant, can be repaired at a central level in this central workplace.



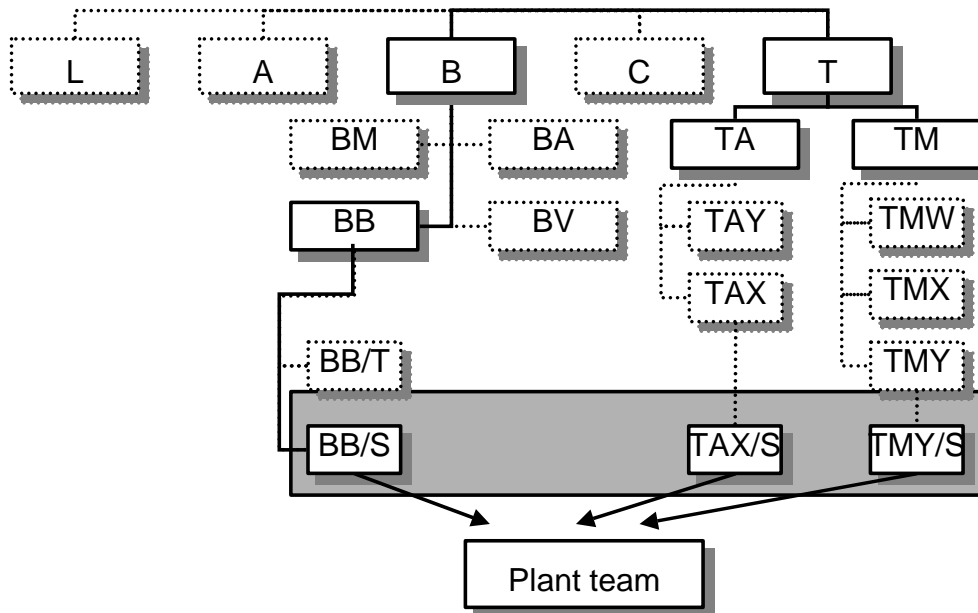
At the teams of TA and TM that work dedicated to the steam cracker, a similar work organisation exists. At the head of TAXS, there is one plant engineer, who is at the same hierarchical level as a plant manager. Beneath him, he has got two assistant plant engineers, one foreman and two corporals. This function of corporal we do not find at the steam cracker. Although these people are formally lower in ranking, they can apparently do the work of a foreman and replace him if necessary. And finally you have got the workers, who do most of the work in the field. And at TMYS you have got a similar structure, with a plant engineer, three assistant plant engineers, one foreman and two corporals who can replace this foreman. And then we find the workers at TMYS, who do most of the mechanical maintenance in the field. Basically, the organisation of the management looks fairly the same in our three teams:

**Table 4.** Organisation of management at BBS, TAXS and TMYS

	BBS	TAXS	TMYS
Plant engineer/manager	1	1	1
Assistant engineer/manager	6	2	3
Foremen	4	1 (+2)	1 (+2)

Note that we have included the corporals with the foremen. Although they are of a lower category as the foremen, they were often referred to in our interviews as being and acting as foremen. So that is why we have included them here.

These three teams keep the steam cracker operating. So we can observe that the steam cracker in operation depends on the close co-operation between the two parallel working divisions, B and T.



**Figure 8.** The plant team

Together, the people from the management teams of B, TA and TM form the plant team. During our interviews, it was stressed that “this is a very important at Company B.” (Interview NB, 28/02/01: 18) Before we discuss the functionality and the importance of such plant team for organisational learning, let us first go a bit deeper into the structure of the composition of this plant team.

In figure° 8, we can clearly see the matrix form of the organisation structure. The people of TA(XS) and TM(YS) provide services to the steam cracker, but they don’t fall under the responsibility of the direction of the steam cracker. So although the people of TAXS and TMYS work ‘for’ the steam cracker, and only for the steam cracker, they are not ‘of’ the steam cracker. They still reside within their own direction.

This calls for close consultation between these teams from the different divisions to keep everybody informed of what is happening at every instant in the entire plant. This is why this plant team plays such a major role in the running of the steam cracker.

This plant team meets twice a day, once in the morning at a quarter past eight and once in the evening at a quarter past five. At this morning meeting, the team leader or the assistant team leader, the foremen and representatives of the management of the plant are present. During this morning meeting, which lasts about fifteen minutes, the team leader on shift reports what has happened in the plant during the last sixteen hours. He gives an overview of how the plant is running, he explains which incidents have happened and whether any accidents have occurred. Then he goes over the production figures of that night. Next, any disturbances that have happened are discussed. After this discussion the plant team draws up a-to-do list by mutual agreement. This enlists all the defects the

operators have noticed during controls and that have to be fixed. It is of great importance that all three parties are present at this moment, because in this way, all the involved parties know what has happened, and which work they have to do and which the other parties have to perform.

During the interviews, one of the operators gave an example of the interconnectedness of the work of the operators and TM and TA.

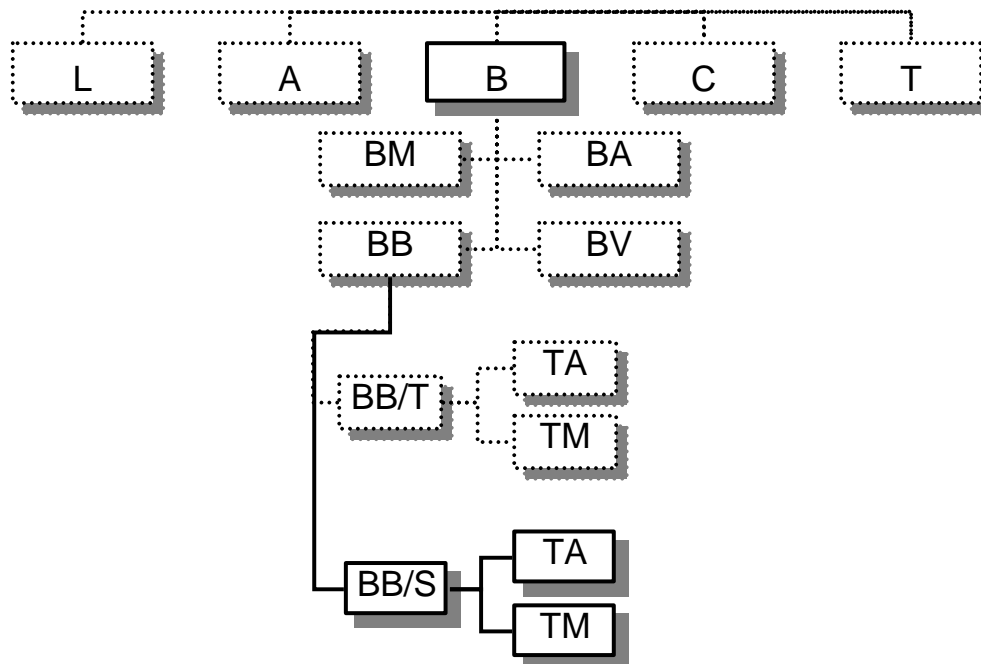
“With TM and TA, we also have a lot of consultation moments. For instance, when a pump breaks down, this pump has got to be rinsed out by the people of TM. But TA has then got to pinch off this motor, and they have got to remove the safety fuse in order to make sure that the motor will definitely not start. So for these things, consultation is absolutely necessary.” (Interview KDV, 03/04/01: 11)

In this way they can all gear their activities to one another. And finally, at the end of the morning meeting, there is still some time for announcements and questions.

At the evening meeting, all parties that are present during the morning meeting are also present during this meeting, but to a lesser extent. Of production usually the same persons are present, but of the technical department, usually one or two persons are. The evening meeting, which can last up till three quarters of an hour, is axed towards the clearing of all the work permits. Here, the team leader of the shift is also the main actor. He prepares these permits in the afternoon shift so the team leader has got to have a good view on which works are necessary for the day after. This entails the main part of this evening meeting. Then the people of the technical department, from TMYS and TAXS, present which works they have performed during the day, and which are still on the worklist. And finally, there is again some time reserved for questions and remarks. So at these meetings a lot of information is transferred between the different parties.

How is this all connected to the concept of organisational learning as used by the members of our research team? First of all, the way in which Company B is organised, with the technical department providing exclusive services to a production plant, makes these intensive meetings between the different involved parties necessary to keep every body well informed. This information flow would otherwise not occur this intensively. But more important maybe, the structure of an independent technical department, which provides services to the steam cracker, provides a structure that stimulates learning and the transfer of knowledge within this technical department. Let us clear out this point.

Let us have a look at the situation in which the services TA and TM provide would be incorporated within the production plants. The division T would then be dismantled and the services that they provide would then be done within the production plants. Suppose we wouldn't change the way in which the functions are composed right now. This means that the job of an operator and the jobs of the technical maintenance and automation people would remain separate jobs.



**Figure 9.** Incorporation of TA and TM within the steam cracker

We can look at this as the incorporation of the now dedicated team of TAXS and TMYS within the supervision of the plant management of the steam cracker. The incorporation of the services which TA and TM provide within the organisation of the production companies wouldn't change much for the meetings they have. This information flow would still be necessary and would probably be as intensive as is the case now. This would only be of influence on the relations between the management of the steam cracker and the management of technical maintenance and automation. Right now, the plant manager and company engineers of TA and TM are hierarchically at the same level, on the understanding that the plant manager of the steam cracker is the *primus inter pares*. When a final decision has got to be reached, he is the one who bears the end responsibility and who has got the last word. If not much would change, why then would we reckon that the structure as it exists today would be better for organisational learning?

If technical maintenance were to be incorporated within the production plants, these people would then loose their strong connection to a technical central division, which would remain operational for work, done at a central level. For instance, pumps that are used on the entire site, and which are not specific to one plant, could still be repaired at a central level, as is the case now. How does this link of these technical workers with their own department affect organisational learning?

One of the criteria of organisational learning as proposed by our research team is that: "knowledge is being created within the organisation, at different levels and it is being shared within the organisation". (Fisher & Roeben, 2001: 137) It is just this knowledge creation and distribution that happens as a result of the

specific situation at Company B. Although the people of TAXS and TMYS work only dedicated to the steam cracker, they still reside under the responsibility of direction T. So as we have stated before, although they work for the steam cracker, they are not of the steam cracker.

Not only do these technical maintenance people from TAXS and TMYS have regular meetings with the people of the production side of the steam cracker, they also have meetings with people who do the technical maintenance for other plants. For instance the company engineer who works for TMYS has got meetings with his fellow engineers from other plants. The same holds for the assistant engineers and the foremen. And the workers are much more in contact with their colleagues who work for different plants. Since the building from where TMYS operates from is shared with other maintenance teams from other plants, this creates learning and knowledge transfer synergy's this way. Problems which workers run into can easily be discussed informally with their colleagues who work for another plant, which can offer refreshing, alternative views on these matters from their own experience. This creates a forum through which new knowledge can be created by bringing together the knowledge of someone with similar experiences in another plant and the problem a worker experiences in maintenance of the steam cracker.

This aspect of organisational learning, where knowledge that is put to the organisations use is created and diffused within the organisation, is also formally acknowledged by Company B through the incorporation of Know How Verbund in their Verbund concept.

What we have tried to show you is how the structural organisation of Company B provides a structure that stimulates the creation and the diffusion of company oriented knowledge. We believe that these structural prerequisites for learning are of great importance

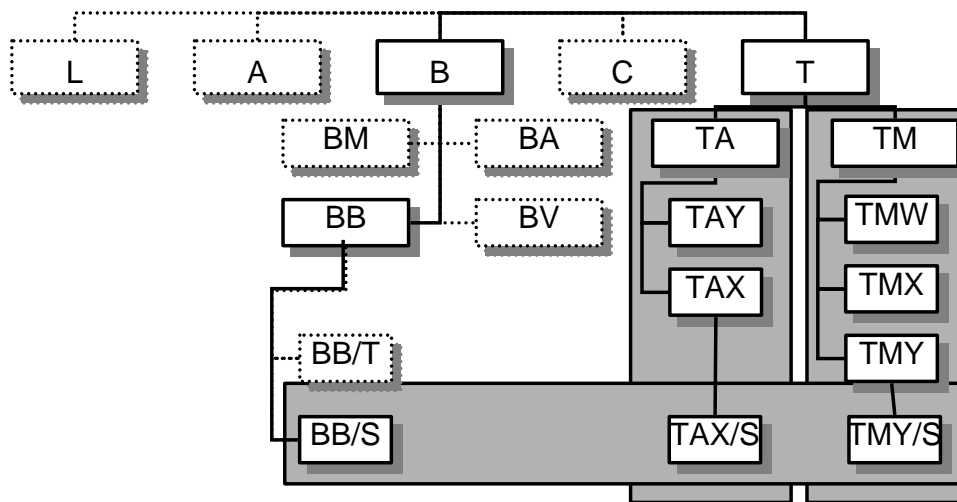
#### 4.3.3 Link to organisational learning

The organisation of Company B provides a structure through which learning is stimulated and which allows for knowledge flows, which would not occur in the to the same extent as outlined when maintenance would be incorporated within the steam cracker.<sup>19</sup> This case thus strongly comply with our first, second and fourth criteria.

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<sup>19</sup> By this, we do not mean the integration of maintenance task within the function description of an operator. This initiative would of course structurally improve the learning possibilities of the operators and their scope of comprehensiveness of the steam cracker. The philosophy behind this idea is best explained using a figure of speech. You don't have to know how the engine of your car works in order to drive it; but if you know how it works, you will drive differently with it. But such an initiative has not yet been undertaken. By this integration, we mean the integration of maintenance personnel who now still reside under the responsibility of an engineer of TA and TM who would then reside under the responsibility of the plant manager of the steam cracker.

This organisation has thus developed a structure through which learning and knowledge exchange is permanently stimulated, in a horizontal way and in a vertical way. How do we have to understand this latter element? Well, let us again take a look at the organisational structure of the steam cracker. We notice two parallel organised department, where a team of maintenance personnel works dedicated to the steam cracker and who come together regularly. This coming together in the plant team can be described as horizontal learning and knowledge exchange. People from different production and maintenance come together in these meetings and exchange knowledge in these meetings and learn from each other.



**Figure 10.** Horizontal and vertical learning and knowledge exchange at the steam cracker

What we have called vertical learning occurs in the maintenance department. This is illustrated by figure° 10. These people work dedicated to the steam cracker but they are not of the steam cracker. Within TA and TM, there are a multitude of maintenance teams who work for certain plants, each with their own engineers, assistant engineers and foremen. These people from these different teams within TA and TM also have regular meetings, in which they exchange experiences about how certain problems are handled in other teams. And because the different teams of maintenance workers of TM all have a place in the central working place, they constantly meet maintenance workers from other plants with whom they can exchange experiences concerning problem solving.

We would like to point out that it is not the structure as such that we have looked upon as a case of organisational learning, but they way that this structure is filled in. The initiatives discussed, as the meetings between BBS and TMYs en TAXS, and the meetings among people of TM and TA, constitute the cases of organisational learning. Thus, the company's policy to ensure the interconnectedness of teams and persons by different means, can be regarded as

one of our cases. As such, it is not the organisational structure in itself, but the way in which this specific matrixstructure has been filled in by the company, that is of importance for organisational learning.

#### **4.4 Handling of critical incidents**

Just after our preliminary interviews had taken place, we had been informed by Company B and the national media that a major disturbance had taken place at the steam cracker. (De Standaard Online, 06/03/01) Luckily, there were no injuries and production could be resumed soon after, although several parts of the installation had been damaged severely.

Although for Company B, this incident was a major setback, it provided us with a unique opportunity to study at a close range how an organisation tackles such a crisis situation. From our research viewpoint, this incident was especially interesting. We could over time follow the changes that had been made throughout the organisation as a response to this (major) disturbance.

This incident provided us with a lucky coincidence. It allowed us to see what part organisational learning played in the handling of the incident. What we are going to do now, is first to have a look at this particular incident, which happened during the night of the fifth of March 2001. What happened and what went wrong? Secondly we will have a look at how this incident was analysed by the people of the steam cracker and how the results of this analysis were transferred to the workers of the steam cracker. Finally, we will have a look at a few initiatives that have been taken concerning training and education as a result of this incident, in order to be better prepared in the future.

##### **4.4.1 The incident of the fifth of March 2001**

In the night of March the fifth, a fire had occurred, which had been “caused by a broken oil pipe at the steam cracker, an installation that is used in processing naphtha and LPG. The oil dripped from the tube and caught fire because of the great heat.” (De Standaard Online, 06/03/2001) As a result, so we read on, a huge fire arose which the fire brigade of Company B couldn’t get under control. Therefore the help of the Antwerp fire fighting team was requested and a crisis centre was set up. Eventually the fire fighters got control over the fire. One of the ovens however was seriously damaged.

At BASF, we were told a similar story but from a different angle. While the newspaper article focussed entirely on the fire, and treated the fire as the incident, we were told that the fire had not been caused by the incident itself, but by a malreaction of a few workers to the incident.

The origins of this incident are to be located in another plant we already encountered in a previous chapter about the organisational structure of Company B, namely Tankpark (BB/T). This plant stores and supplies the basechemicals to be transformed to the other plants. Apparently, the feedstock was shut down and instantly reopened again, without the steam cracker being notified of this action beforehand. Because of the flow-nature of processes, this created a cascading effect of things going wrong. Add a few malreactions of the workers to this 'snowball' effect, and what was a small, seemingly controllable incident in the beginning, soon led to a complete shutdown in a few instants.

#### 4.4.2 Analysis of the incident at the steam cracker

At the time of the incident, all people were called upon that could help. For crisis situations like these, a special plan has been devised that was operational at that time. This meant amongst others that the plant management is permanently present at the steam cracker in two shifts. At this time, there is no time for analysis of the incident. What is tried, is to stabilise the plant as much as possible in order to get it running as soon as possible.

"At that time, you haven't got the time to think about it." (Interview GVC, 05/04/01: 9)

In the days after, an analysis was made by the plant management of what happened and what went wrong, since this was not clear at the beginning. The method of analysis they use is by drawing up a kind of 'facts tree', of what went wrong where at what time. This way, possible causes are noted and looked at from different angles.

For drawing up such a facts tree, use is made of the recorded measurements. The actions of the workers are also being documented by means of letting the workers put their experiences during the failure down in writing. By using such a methodology, they have put all the pieces of the puzzle together and have worked their way up to the very beginning of the incident. In this way, a report was drawn up of what had happened from minute to minute, in order to map all the failures.

So in uncovering this disturbance, all the workers on shift were actively involved in helping to map what went wrong. Of course, also a normal incident report had been drawn up for this incident, as is the normal procedure. But extra actions followed in order to prevent such incidents from happening again. The plant manager told us:

"Such an incident is run through with the team who has gone through it, to make sure this team knows which mistakes were made and how to react in the future. It becomes harder to get all the information to seep through to the other teams. But therefore we have got a system of incident reports, which are sent to all four teams. (...) Sometimes it is hard to get the finesse into a team. We have had a fairly big disturbance now, so I think I will go through this disturbance separately



with all the different teams. The incident was so big, I want to go through it orally with each team. And to put all this experience in one incident report is also fairly difficult.” (Interview FW, 05/04/01: 12)

From the management point of view, a shut down is undesirable. For the education of an operator, a shutdown and the subsequent start-up provide a fabulous training, where in a few weeks, they can learn more about the plant, then in a year when the plant is running smoothly.

“Actually, it is the best way of learning for us. When the plant shuts down unplanned, this is bad for the company, but it is brilliant for us. I mean, you have got a bigger margin to work within because you are already out, and you have to do everything from scratch (...) which is the best lesson you can get.” (Interview FVDB, 03/04/01: 9)

So the operators look upon an incident as an ideal learning moment, because during a disturbance, experiences can be acquired with situations that only rarely happen, yet which are vital. The viewpoint of the management is a bit different. They also regard an incident as a learning moment, but not so much during the incident itself but more afterwards. As the plant manager told us:

“If you encounter a disturbance, and you have lost your capacity for two or three weeks, my first reaction is not: ‘Ho, ho, this is a good learning moment’. No, at that time, we are in sackcloth and ashes, and we curse. Then we say: ‘Damned, how could this have happened to us again’. Afterwards, when the plant is running again, you can say: ‘Now I want every one to know what went wrong there.’ Then you begin to look at that incident from a different angle, and you start to treat it more like a learning moment. But at the moment when we are in it, we don’t say: ‘Well done men, we have trained our men well’.” (Interview FW, 05/04/01: 13)

We have already stated that some unfortunate reactions of some operators made the incident escalate even more. In order to still be able to look upon disturbances as learning possibilities, it is essential that no individual guilt is attributed.

#### 4.4.3 Automation paradox

In the description of the competence management at the steam cracker, we have already referred to this paradox when we discussed the ‘Procesverstehen’ as an essential competence for a worker. In the highly automated working environment of the steam cracker, the operator barely has to intervene when the process is running smoothly. However, in case of a disturbance, he has to be able to detect errors fast and accurately, to diagnose them and to fix them. (Sels, Van Hootegeem, 1993: 172) His labour becomes a stochastic event, an unpredictable and unstandardizable event. But the more the plant becomes automated and the less disturbances occur, the less experience an operator can acquire in order to learn how to handle a disturbance.

Thus because of more automation, he loses his 'feeling' for the process, which is crucial for a good intervention in case of a disturbance. Although it may seem that through more automation the human factor becomes more obsolete, the opposite is true. The human factor is very important in response to a disturbance. This is what constitutes the paradox. Because of more automation, you have to rely more on your worker when something goes wrong. And furthermore, because fewer disturbances occur because of more automation, he is not able to acquire the essential skills of reacting adequately in case something goes wrong. More automation is thus not always beneficial for the company, especially not in case something goes wrong. This is what the automation paradox shows.

Continuous knowledge transfer, regular practice of the required skills and permanent socialisation must allow for the knowledge, skills and attitudes to be kept up to date. This is where the process simulator, as it has been installed at the steam cracker, can play a very important role.

This simulator is a separate console in the control room, which looks and responds just like an actual console, except for the fact that nothing changes for real in the installation itself. A computer programme simulates the responses of the installation outside on the console. Workers can acquire experience with disturbances through simulating disturbances on this separate console. But as one of the workers reports: "We have used the simulator frequently during the start-up of the installation. Afterwards it has been used less often, because it is a bit outdated". (EDB, 29/03/02: 6) At the moment, management is re-evaluating the usability of this simulator, because of the high expenses of keeping the simulation programme up to date.

According to us, against the background of the automation paradox, the simulator can play an essential role in updating the skills needed to deal with a disturbance.

#### 4.4.4 Initiatives

In this part, we will look at which initiatives have been taken as a result of the disturbance. There for we went back to the steam cracker and had a follow-up interview with the assistant plant manager.

Besides numerous technical changes in the plant itself, two other changes are of importance to us.

An obligatory plan for training at the steam cracker has been drawn up for new workers during their first year at the steam cracker.<sup>20</sup> This plan consists out of two different modules. A first module, which already existed, is presented to the worker during the first six months.

"This module contains general things, which are very relevant. That is something we have experienced during the disturbance." (Interview NB, 05/09/01: 1)

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<sup>20</sup> This education plan is only for new workers who begin at an Aa-level. New workers who start at the steam cracker, but who have got experience in the chemical industry usually begin at a higher level.

This existent module has been expanded upon with a second module, which runs from month six until twelve. This module contains practical questions related to key issues at the steam cracker. These questions are meant to be used by the novice worker to improve his comprehension of the site. They are thus not regarded as a test. With these two modules, the management of the steam cracker tries to “improve the availability of the workers, by providing them with a similar basis after one year.” (Interview NB, 05/09/01: 2)

A second initiative concerns the evaluation of a worker. Previously, this evaluation was only done by the team leader, and management was almost not involved. After six months, a newcomer has now also got an evaluation by the plant manager. During this conversation, the plant leader also asks for knowledge acquired during the first module. This is not conceived of as a kind of test. Furthermore, when someone has finished with a specific console (cold I, cold II and hot/auxiliary), there is also an evaluation of his work by the plant manager. It was stressed upon that this is not a test, just a way of finding out what the mans strengths and weakness are and how to improve on them.

#### 4.4.5 Link to organisational learning

This case shows us the measures this company has taken after something seriously has gone wrong. Several technical measures have been taken which Argyris and Schön would call single loop learning. But we can also observe a higher order of learning in this case, namely that of more fundamental changes in trying to get all the different learning cultures of the different teams aligned, by participating in the evaluation process of workers, and by providing feedback. Thus trying to establish a cultural transformation between the teams. The new way of registering competencies can also be interpreted in this respect.

Furthermore, just the fact that these changes take place as a result of the incident, could be regarded as organisational learning. The work routines have been evaluated as a result of the incident, and changes have been made, thus the organisation has learned from this experience. This incident has been discussed in detail with the different teams, and this incident has been and will be the subject of several project meetings at the steam cracker. So a lot of knowledge is created and shared. And since two experts from another department assisted the people of the steam cracker during the audit of the incident, we can also say that learning from the environment has taken place. All this information has also been conveyed to the people of the steam cracker in Ludwigshafen, thus stimulating organisation learning.

## 5. Conclusion

In this paper we have presented you with a concise theoretical framework. Then we have presented our four different cases of organisational learning. The danger is of course that these cases are looked upon independently from each other and are regarded as four separate cases. This could lead to misunderstanding, since these cases are of course strongly interrelated to each other. This paper should therefor be looked upon as a whole, with all cases intertwined. That is why we present you a conclusive matrix in which all cases are presented according to our five criteria of organisational learning.

**Table 5.**

Criteria	Work routines	(In)formal learning	Cultural transformation	Knowl. creation & sharing	Environ-ment
Revaluation of SOP					
Plant manual					
Suggestion					
Idea manager					
Incident report					
Grey booklets					
Competence management					
Organisational structure					
Handling of critical incidents					

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